Physics

V. L. Broude, V. V. Eremenko, and N. N. Chikovani

1958

SovietRxiv

Fig. 1

Figure 1: Fig. 1

Abstract

Full Text

Physics

V. L. Broude, V. V. Eremenko, and N. N. Chikovani

Structure of the Absorption and Photoconductivity Spectra of CdS Crystals at 20 °K

(Presented by Academician A. N. Terenin on 6 XII 1957)

In our previous work (^{1}) and in the works of E. F. Gross and co-workers (^{2,3}), it was established that the narrow-line absorption in the region 20400–20600 cm^{-1} is variable and has an impurity character. The shorter-wavelength absorption, as was indicated, is stable. It therefore seemed of interest to measure the coefficients of light absorption by CdS crystals in the shorter-wavelength region and to estimate quantitatively the changes in line intensities associated with lattice distortions. To establish the nature of the photoconductivity, it was important to compare the spectral distribution of the absorption coefficient with the spectral distribution of the stationary photocurrent.

The investigation was carried out at 20°K. A metal cryostat with plane windows (^{4}) was used, in which the sample was cooled by vapors of boiling hydrogen. The photoconductivity was measured on a Leitz glass monochromator with an extended camera ($F = 1$ m). The linear dispersion in the wavelength interval studied was 18–20 Å/mm. The spectral width of the slit could be chosen to be no less than 3 cm^{-1}. Each division of the monochromator drum corresponded to 7 cm^{-1}. The photocurrent was measured with a mirror galvanometer of sensitivity $2 \cdot 10^{-9}$ A. The light source was a 400-watt incandescent lamp; the polarizer was a Glan-Thompson prism. The sample was arranged in such a way that the c axis made an angle of 45° with the slit of the monochromator or spectrograph; this eliminated errors associated with the polarization of light upon reflection from the prisms of the instrument.

Fig. 1

The absorption coefficient was measured by the method of photographic photometry using a 9-step attenuator. Photometry was performed on an MF-2 microphotometer. The error in determining the absolute value of the absorption coefficient reached 30%—mainly because of the inaccuracy in measuring the

Fig. 2

Figure 2: Fig. 2

crystal thickness (20%). The relative error in the distribution $x(\lambda)$ did not exceed 7%. No correction for reflection was introduced. This introduces an error of 10% in determining the absolute value of x, but it practically does not distort the curve of the spectral distribution of x.

We were able to measure the absorption curve up to the frequency 20860 cm^{-1} (maximum value $\chi = 4.2 \cdot 10^{-2}$) for light polarized along the c axis, and up to the frequency 20680 cm^{-1} in the strong component of the spectrum. Figure 1 gives the curves of the spectral distribution of the absorption coefficient of light polarized parallel and perpendicular to the optical axis of a CdS crystal at 20°K. Beginning with the frequency 20625 cm^{-1} ($\chi \simeq 0.007$), light in a crystal 15-20 μ thick is absorbed practically completely.

Fig. 2

The absorption of light in the region of frequencies greater than 20600 cm^{-1} is sufficiently stable in different specimens, and the curves obtained on different crystals "matched up" within the limits of measurement error. An entirely different picture is observed in the region of the longer-wavelength, narrow-line absorption, which varies very strongly from specimen to specimen. Thus, in Fig. 1, in the c-component, the absorption in bands 9-10 (the numbering is the same as in (1)) is shown by a dashed and a solid line for two different crystals. It is seen that the absorption coefficient in band 10 changes by tens of times. By a dashed line in the region of bands 12 and 14 are marked portions that were distorted during photometry with a wide slit on the spectrograph; the structure in these portions is clearly visible in photographs of the spectra.

In the region of stronger absorption we did not succeed in measuring the curve $\chi(\lambda)$, since we did not have thin crystals of sufficient dimensions. However, we compared the absorption curves obtained with photographs of the spectra of thinner crystals available to us and in the literature (^{3}). In Fig. 2 the curves of the spectral distribution of photoconductivity and of the absorption coefficient are compared. The extrapolated part of the absorption curve is drawn with a dashed line.

From the comparison in Fig. 2 A it follows that, for polarization of light along the optical axis of the crystal, the first photoconductivity peak corresponds to the rise on the absorption-coefficient curve in that part of the spectrum where the absorption does not vary from specimen to specimen. The subsequent increase of χ leads to a decrease in the photocurrent, but the photocurrent reaches a minimum not at the maximum value of χ, but on the short-wavelength fall of band 13. The second photocurrent peak is also situated on the rise of the absorption curve (band 16).

Comparison of the absorption and photoconductivity spectra for polarization perpendicular to the c axis (Fig. 2 B) shows that the first photocurrent maximum is located in the region of lines 4–10, on the rise of band 10, and the second maximum is on the rise of the curve in the region of band 13.

It should also be noted that on the photoconductivity curve in the c-component there are no changes in the region of line 10, although its maximum in this component corresponds to $\chi = 0.02$ and in some samples reaches values $2.2\text{–}3 \cdot 10^{-2}$. This once again indicates that the lattice disturbances with which absorption in this line is associated are localized in the near-surface photo-inactive layer of the crystal.

At the suggestion of É. I. Rashba, a comparison was made of the values of the steady-state photocurrent at different wavelengths corresponding to identical values of the absorption coefficient. With light polarized along c, in the measured part of the spectrum one and the same value of χ can be encountered three times at different wavelengths. The result of the comparison is given in Table 1.

Table 1

ν, cm^{-1}	$\chi \cdot 10^2$	I_ϕ, arbitrary units
20650	2.25	170
20770	2.25	110
20825	2.25	152
20664	2.50	173
20760	2.50	100
20843	2.50	144
20658	2.75	178
20757	2.75	97
20845	2.75	147
20662	3.00	182
20753	3.00	91
20848	3.00	146
20670	3.25	190
20746	3.25	82
20852	3.25	148

$$\chi = 0.03 \text{ at } \nu = 20\,662 \text{ cm}^{-1}; \qquad k = 7.8 \cdot 10^3 \simeq 10^4 \text{ cm}^{-1}.$$

As we see, there is no one-to-one correspondence between the steady-state photocurrent and the absorption coefficient of light. This fact indicates that the dependence of photoconductivity on the absorption coefficient is complicated by an explicit dependence of the photocurrent on the wavelength of the absorbed light, which must be taken into account in establishing the mechanism of photoconductivity in CdS single crystals.

We take this opportunity to express our gratitude to A. F. Prikhot' ko and É. I. Rashba, who took an active part in the discussion of the present work.

Institute of Physics
Academy of Sciences of the Ukrainian SSR

Received
4 XII 1957

CITED LITERATURE

1. V. L. Broude, V. V. Eremenko, É. I. Rashba, *Ukr. Fiz. Zhurn.*, **2**, 96 (1957); DAN, **114**, 520 (1957).
2. E. F. Gross, B. S. Razbirin, M. A. Yakobson, ZhTF, **27**, 1149 (1957).
3. E. F. Gross, B. S. Razbirin, ZhTF, **27**, No. 9 (1957).
4. V. L. Broude, V. S. Medvedev, A. F. Prikhot' ko, *Optika i spektroskopiya*, **2**, 317 (1957).

Note: Figure translations are in progress. See original paper for figures.

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.